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(71) Applicant: **FISHER & PAYKEL LIMITED**
78 Springs Road
East Tamaki, Auckland(NZ)

(72) Inventor: **Sims, David John**
37A Oakdale Road
Hillsborough, Auckland(NZ)

(74) Representative: **Brown, John David et al**
FORRESTER & BOEHMERT
Franz-Joseph-Strasse 38
D-80801 München (DE)

(54) **Humidifier with dual float valves.**

(57) A humidification chamber (1A) for a respiratory humidifier (30) in which a level of liquid water is maintained by the use of floats (2, 3) which actuate valves (8, 10 and 9, 11) to control the passage of water through a water inlet (4). Two floats (2, 3) are each provided with actuating mechanisms to separately control the respective valve members (10, 11). The separate valve members (10, 11) are covered by an elastomeric moulding (12, 21, 22) which couples the valve members (10, 11) and provides a seal. The valves (8, 10 and 9, 11) are co-axially aligned and the system provides improved safety by allowing for reliable operation in the case where one of the floats (2, 3) fails. An alternative embodiment of the dual valve construction is also disclosed.

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BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to float valve systems and in particular but not solely float valve systems for respiratory humidification systems.

Description of the Prior Art

A respiratory humidification system includes a humidifier which is supplied with liquid water flow and a flow of gases (for example air including oxygen or an anaesthetic gas). The aim of the humidifier is to combine some of the water in the form of water vapour with the gas, thus raising the level of humidity of the gases and making it easier for a patient in a hospital or someone else in need of such gases to inhale them.

A humidifier in which the gases absorb water vapour from water or a water laden surface usually comprises a humidification chamber containing water and a heater base used to evaporate the water. A crucial aspect of respiratory humidifiers is in the control of the liquid water flow. It is imperative that liquid water not be allowed to pass directly to the patient for obvious reasons. Therefore, within the humidification chamber water valves are commonly used in various configurations to regulate the water flow.

Some prior art water valve mechanisms have been of a single valve type, configured with actuating means in order to stop the water entering the humidification chamber. An example is described in our United States Patent No. 4,913,140. A solitary valve may give rise to difficulties in regard to reliability, as a problem with, for example, the valve seal or the actuating mechanism may cause overfilling. For this reason, prior respiratory humidification systems have introduced double valve mechanisms in a bid to increase reliability and thus the safety of the humidifier. An example is United States Patent No. 4,529,867 to Velnosky et al. The double water valve mechanism described by Velnosky however, does not attempt to halt the flow of liquid water but merely to direct it elsewhere. A double valve configuration is disclosed in the aforesaid United States Patent No. 4,913,140.

It is, therefore, an object of the present invention to provide a float valve and/or a respiratory humidifier which provides the public with a useful choice.

DISCLOSURE OF THE INVENTION

Accordingly in one aspect the invention consists in a float valve system for controlling the level of liquid in a chamber comprising a valve body

having an inlet for coupling to a liquid supply conduit and an outlet adapted to communicate with said chamber,

said float valve system characterised in that a first valve seat formed in said body through which liquid must pass to reach said outlet,

a second valve seat formed in said body located downstream of said first valve seat, through which liquid must pass to reach said outlet,

first and second floats adapted to be disposed within said chamber,

a first valve member actuated by said first float so as to close onto said first valve seat on the first float assuming a position corresponding to a first predetermined level of liquid in said chamber, and

a second valve member actuated by said second float so as to close onto said second valve seat on the second float assuming a position corresponding to a second predetermined level of liquid in said chamber, said second predetermined level of liquid being higher than said first predetermined level of liquid.

In a second aspect the invention consists in a respiratory humidifier including a water chamber adapted to be heated through which gas to be humidified is passed and a float valve system for controlling the level of water in said water chamber, said float valve system comprising a valve body mounted in the wall of said chamber having an inlet for coupling to a water supply conduit and an outlet opening into said chamber,

said respiratory humidifier characterised in that a first valve seat formed in said body through which water must pass to reach said outlet,

a second valve seat formed in said body through which water must pass to reach said outlet, located downstream of said first valve seat,

first and second floats disposed within said chamber,

a first valve member actuated by said first float so as to close onto said first valve seat on the first float assuming a position corresponding to a first predetermined level of water in said chamber, and

a second valve member actuated by said second float so as to close onto said second valve seat on the second float assuming a position corresponding to a second predetermined level of water in said chamber, said second predetermined level of water being higher than said first predetermined level of liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention consists in the foregoing and also envisages constructions of which the following gives examples.

Preferred forms of the present invention will now be described with reference to the accom-

panying drawings in which:

Figure 1 is a cross-sectional elevation of a humidifier chamber incorporating the valve system of the present invention showing a normal water level;

Figure 2 shows the humidifier chamber of Figure 1 devoid of liquid water;

Figure 3 shows the humidifier chamber of Figure 1 in which the primary shut off system has failed and the secondary system is controlling the liquid water level;

Figures 4, 5, 6 and 7 show the valve system of Figure 1 in the following modes of operation;

Figure 4: Both valves open Figure 5: Primary valve closed, secondary valve open

Figure 6: Both valves closed

Figure 7: Primary valve open, secondary valve closed

Figure 8 is an alternative embodiment of the present invention; and

Figure 9 shows a respiratory humidifier including the valve system of Figure 7.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Figures 1, 2 and 3, a humidification chamber 1A for fitting to a respiratory humidifier 30, for example as shown in Figure 9, is made up of a preferably transparent humidification chamber moulding 1 which is sealed to an aluminium heat transfer base 6 by a process which forms an annular lip around the humidification chamber. An external water reservoir (not shown) supplies liquid water to the humidification chamber 1A through a water inlet 4 in use. The humidification chamber 1A contains water in both liquid and vapour phases and is similar in construction to that disclosed in United States Patent No. 4,913,140 and should be operated with the base 6 in a substantially horizontal plane.

Liquid water enters the humidification chamber 1A through inlet 4 and rises against the walls of the humidification chamber to a level dependent on the amount of water allowed to enter the chamber. A double float arrangement is shown within the humidification chamber 1A made up of two independent air filled, sealed plastic mouldings which are able to rise and fall with the water level. The operation of this double float valve system is described below.

A first or primary float 2 is fabricated to include an arm 13 which is connected by a pivot 16 to a hinge moulding 14 which is further bonded to the humidification chamber moulding 1. A second or secondary float 3 operates in conjunction with primary float 2 as a safety improvement system. The secondary float 3 is pivoted at 18 by a connection

with the hinge moulding 14. The lower surface of secondary float 3 is provided with a foot 20 positioned near the end of the secondary float 3 furthest from the pivot 18 in order that the secondary float 3 may not fall to a position below a predetermined height. The humidification chamber 1A is further equipped with a gases inlet (not shown) and a gases outlet 5. In the process of humidification, the base 6 of the humidification chamber 1A is provided with heat from a controlled source of heat (not shown), causing vapour to rise from the surface of the liquid water which mixes with the gases (for example, air including oxygen or anaesthetic gas).

The primary float 2 and secondary float 3, as shown, are preferably located concentrically both within the humidification chamber 1A and relative to each other. This arrangement is such that upon the humidification chamber 1A being tilted from a substantially horizontal plane, water level changes adjacent to the gases inlet (not shown) and gases outlet 5 are minimised. The secondary float 3 is physically larger in size than the primary float 2 and occupies a significant volume of chamber 1A. The reason for the relative volumes and shapes of the chamber and floats is to minimise the compressible volume of the humidification chamber 1A and also so that gases in the humidification chamber 1A may be directed to effect more efficient humidification. In addition the larger size of the secondary float 3 is useful in giving an increased closing force of the valve moulding 12 onto the valve seat 9. It is to be understood that the floats 2 and 3 could be the same size or be located beside each other in the humidification chamber.

The water inlet 4 incorporates a two stage valve arrangement which, in use, is substantially oriented in the vertical plane. The section of the water inlet 4 facing the valve mechanism is specially constructed with a primary valve seat 8 and the secondary annular valve seat 9. The valve actuating mechanism comprises an inner push rod 10 within a preferably co-axial outer cylindrical push tube 11, both capable of moving freely and independently within limits. The end of the push rod 10 facing the water inlet 4 is tapered to a blunt point 15 and covered by an elastomeric valve moulding 12, manufactured in such a shape as to also fit snugly over the rim of the outer push tube 11, thus coupling the push tube 11 to the push rod 10 in a floating connection. The elastomeric valve moulding 12 is made of material which is very supple but strong, for example, the material sold under the trade mark KRATON as supplied by Shell Corporation, or a silicone rubber as supplied by Dow Corning (Medical) would be suitable.

The water inlet 4 may also include a flexible membrane 23 which operates as a non-return valve

to prevent water or gas travelling in a direction from the humidification chamber 1A to the water inlet 4.

The push rod 10 of the valve mechanism has, at its lower end, a pivot 17 to the arm 13 of the primary float 2, near the connection 16 of the hinge moulding 14 and the arm 13. The push tube 11 is pivoted at its lower end by a hollow ball joint which attaches it to the secondary float 3 near the connection 18 of the hinge moulding 14 and the secondary float 3.

With reference to Figures 4, 5, 6 and 7, the arrangement and operation of the valves according to the present invention will now be described.

An inner push rod 10 is surrounded cylindrically by an outer push tube 11, both of which can move independently but are loosely coupled by an elastomeric valve moulding 12 at their respective ends facing the water inlet 4. The valve moulding 12 forms a seal with either, or both, of the valve seats 8 and 9. Both the push rod 10 and the push tube 11 move in substantially a vertical plane, the push rod 10 being controlled by the actions of the primary float 2 and the push tube 11 displaced in reaction to movement of the secondary float 3. In Figure 4 it can be seen that a gap exists between the valve moulding 12 at the region covering the push tube shoulders 19 and the secondary valve seat 9. Also, a gap exists between the valve moulding 12 in the region covering the tapered part of the push rod 10 and the primary valve seat 8. Thus, Figure 4 displays a state in which both valves are open so that water may flow into the humidification chamber 1A from the external reservoir. The float arrangement giving rise to this eventuality is illustrated in Figure 2 where both floats are lowered and there is substantially no liquid water in humidification chamber 1A. The same configuration of valves is occasionally found in the situation described by Figure 1 in which the primary float 2 is actively controlling the water level by periodically raising the push rod 10 to form a seal between the primary valve seat 8 and the portion of valve moulding 12 covering the tapered section of push rod 10. This configuration is shown in Figure 5 for an instant in time when the primary valve is closed and the secondary valve is open. In this situation no water will flow into the humidification chamber 1A.

If a situation were to occur as depicted in Figure 3 where the primary valve has not functioned (for example there may be a leak in the seal), the water level will be significantly higher so that the primary float 2 will be substantially or fully submerged and the secondary float 3 will come into play. It is vital that the water level should not increase to a level whereby liquid water would be forced out of the gases outlet 5 and into the

patient. Therefore, due to the rising water level, the secondary float 3 will raise the push tube causing the region of the valve moulding over the shoulder 19 of the push tube 11 to form a seal with the secondary valve seat 9. The valve positions for this occurrence are shown in Figure 6.

There may also arise a situation where the primary float 2 may fail and not close the primary valve (for example, if float 2 develops a hole). In this situation, the water level will rise above the primary float (as in Figure 3) until the secondary float is activated. The secondary float will close the secondary valve and then actively control the water level within the humidification chamber 1A. The valve positions arising from this sequence of events may be seen in Figure 7. Thus although the primary valve may have malfunctioned, the secondary valve can, when needed, be relied upon to close and then open again if necessary due to an inadequate amount of liquid water in the humidification chamber 1A.

An alternative preferable embodiment of the present invention is shown in Figure 8. It can be seen that the push rod 10 and the push tube 11 are incorporated in the water inlet 4 as before. The primary float 2 and secondary float 3 are not shown but are connected to the two valve members as previously described. The push rod 10 and the push tube 11 are not coupled by an elastomeric valve moulding but instead there is now an elastomeric primary valve moulding 22 and a separate elastomeric secondary valve moulding 21. In this embodiment, water flows into the chamber from the valve cavity and down the space between the push rod and the push tube.

The operation of the valve mechanism of this alternative preferred embodiment will now be described. Upon the primary float 2 rising in response to an increase in the water level of the humidification chamber 1A, the push rod 10 will be forced to rise. On occasion, the push rod 10 may rise sufficiently to cause the elastomeric primary valve moulding 22 to come into contact with the primary valve seat 8. This would constitute closure of the primary valve, causing a stoppage to the flow of water from the external reservoir (not shown) to the humidification chamber 1A.

The secondary valve mechanism encompasses a secondary valve seat 9 which is formed as part of the push tube 11 with its attached elastomeric secondary valve moulding 21. If circumstances were to arise in which the secondary float 3 was to rise sufficiently in response to an increase in water level in the humidification chamber 1A to allow the region of the valve seat 9 over the shoulders of the push tube 11 to contact the region of push rod 10 adjacent valve seat 9, then the secondary valve would be closed and no water would flow into the

humidification chamber 1A from the external reservoir (not shown).

The float valve system according to at least the preferred form of the invention has the advantage of providing a safety factor in controlling water flow into a humidification chamber. Should the first float valve fail, observation through a transparent chamber wall will show this malfunction, but even if such observation is delayed, the second float valve should adequately take over control.

The features disclosed in the foregoing description, in the claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

1. A float valve system for controlling the level of liquid in a chamber (1A) comprising a valve body having an inlet (4) for coupling to a liquid supply conduit and an outlet adapted to communicate with said chamber (1A),

said float valve system characterised in that a first valve seat (8) formed in said body through which liquid must pass to reach said outlet,

a second valve seat (9) formed in said body located downstream of said first valve seat (8), through which liquid must pass to reach said outlet, first (2) and second (3) floats adapted to be disposed within said chamber (1A),

a first valve member actuated by said first float (2) so as to close onto said first valve seat (8) on the first float (2) assuming a position corresponding to a first predetermined level of liquid in said chamber (1A), and

a second valve member actuated by said second float (3) so as to close onto said second valve seat (9) on the second float (3) assuming a position corresponding to a second predetermined level of liquid in said chamber (1A), said second predetermined level of liquid being higher than said first predetermined level of liquid.

2. A respiratory humidifier as claimed in claim 1 wherein said valve seats are coaxial.

3. A respiratory humidifier as claimed in claim 1 wherein said second valve member is actuated by said second float (3) through a cylindrical actuating member (11) and said first valve member is actuated by said first float (2) through an inner actuating member (10) disposed within said cylindrical actuating member

(11).

4. A respiratory humidifier as claimed in claim 1 wherein said second valve member is actuated by said second float (3) through a cylindrical actuating member (11) and said first valve member is actuated by said first float (2) through an inner actuating member (10) disposed coaxially within said cylindrical actuating member (11).

5. A respiratory humidifier as claimed in any of claims 1 to 4 wherein said first and second valve members are formed from a common unitary elastomeric membrane (12), the central region of which forms the first valve member and the concentric outer region of which forms the second valve member.

6. A respiratory humidifier as claimed in claim 5 wherein said elastomeric membrane (12) is fitted about the adjacent ends of said inner (10) and cylindrical (11) actuating members and the valve members are each closed by said members pushing respective regions of said membrane (12) into sealing engagement with said valve seats.

7. A respiratory humidifier (30) including a water chamber (1A) adapted to be heated through which gas to be humidified is passed and a float valve system for controlling the level of water in said water chamber, said float valve system comprising a valve body mounted in the wall of said chamber having an inlet (4) for coupling to a water supply conduit and an outlet opening into said chamber (1A),

said respiratory humidifier characterised in that a first valve seat (8) formed in said body through which water must pass to reach said outlet,

a second valve seat (9) formed in said body through which water must pass to reach said outlet, located downstream of said first valve seat (8),

first (2) and second (3) floats disposed within said chamber (1A),

a first valve member actuated by said first float (2) so as to close onto said first valve seat (8) on the first float (2) assuming a position corresponding to a first predetermined level of water in said chamber (1A), and

a second valve member actuated by said second float (3) so as to close onto said second valve (9) seat on the second float (3) assuming a position corresponding to a second predetermined level of water in said chamber (1A), said second predetermined level of water

being higher than said first predetermined level of liquid.

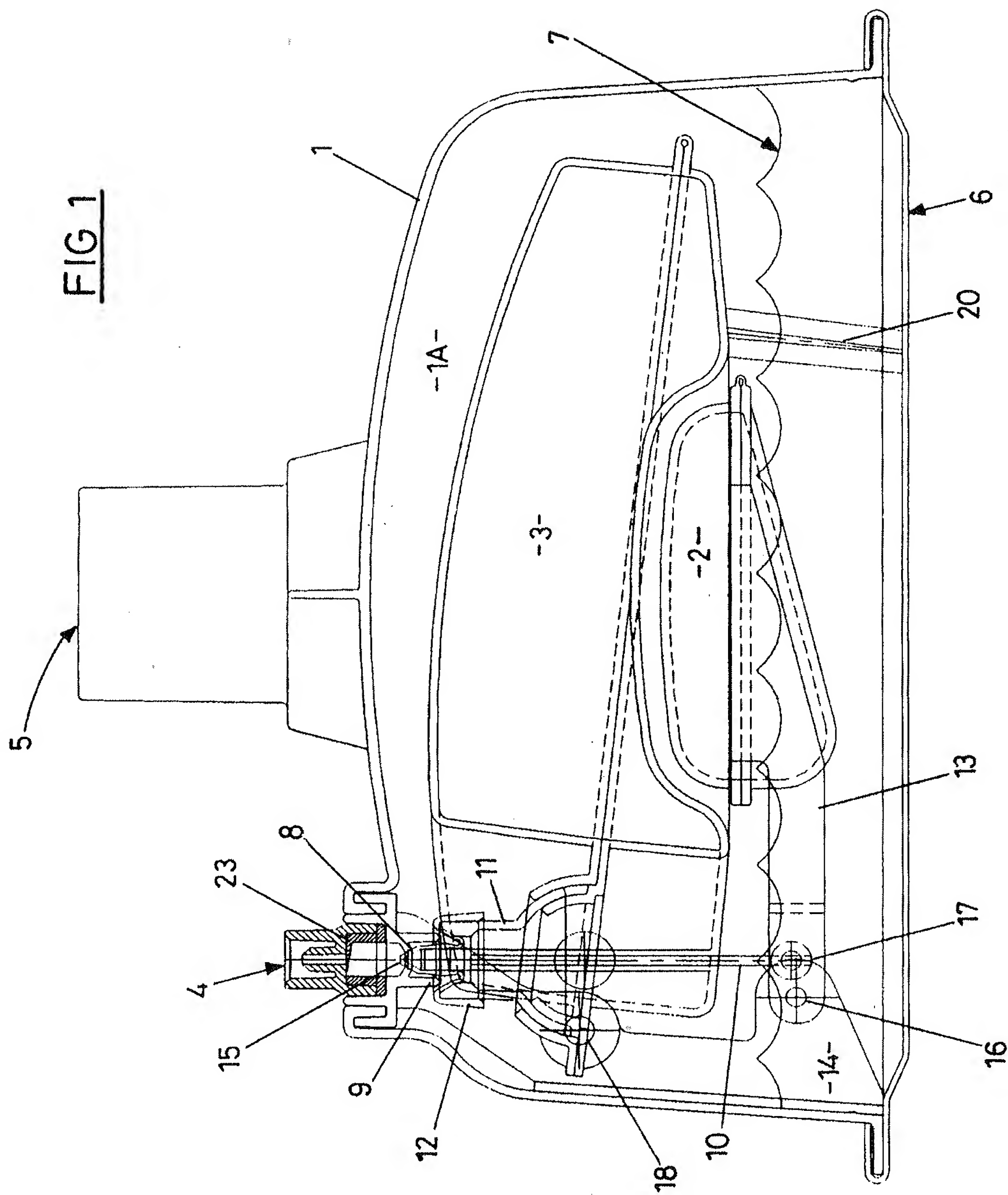
8. A respiratory humidifier (30) as claimed in claim 7 wherein said valve seats are coaxial. 5
9. A respiratory humidifier (30) as claimed in claim 7 wherein said second valve member is actuated by said second float (3) through a cylindrical actuating member (11) and said first valve member is actuated by said first float (2) through an inner actuating member (10) disposed within said cylindrical actuating member (11). 10
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10. A respiratory humidifier (3) as claimed in claim 7 wherein said second valve member is actuated by said second (3) float through a cylindrical actuating member (11) and said first valve member is actuated by said first float (2) through an inner actuating member (10) disposed coaxially within said cylindrical actuating member (11). 20
11. A respiratory humidifier (30) as claimed in any of claims 7 to 10 wherein said first and second valve members are formed from a common unitary elastomeric membrane (12), the central region of which forms the first valve member and the concentric outer region of which forms the second valve member. 25
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12. A respiratory humidifier (30) as claimed in claim 11 wherein said elastomeric membrane (12) is fitted about the adjacent ends of said inner (10) and cylindrical (11) actuating members and the valve members are each closed by said members pushing respective regions of said membrane (12) into sealing engagement with said valve seats. 35
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FIG 1



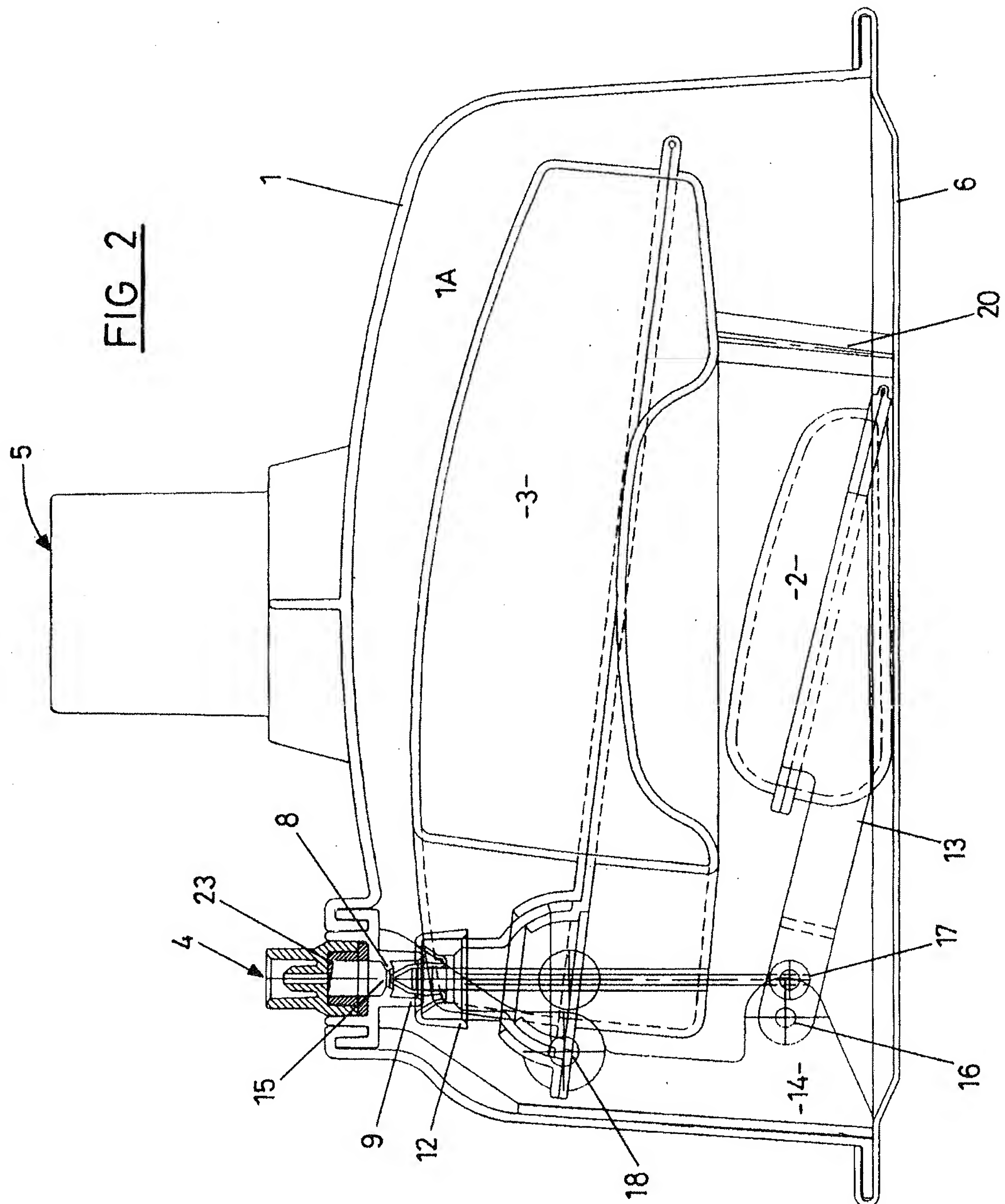


FIG 3

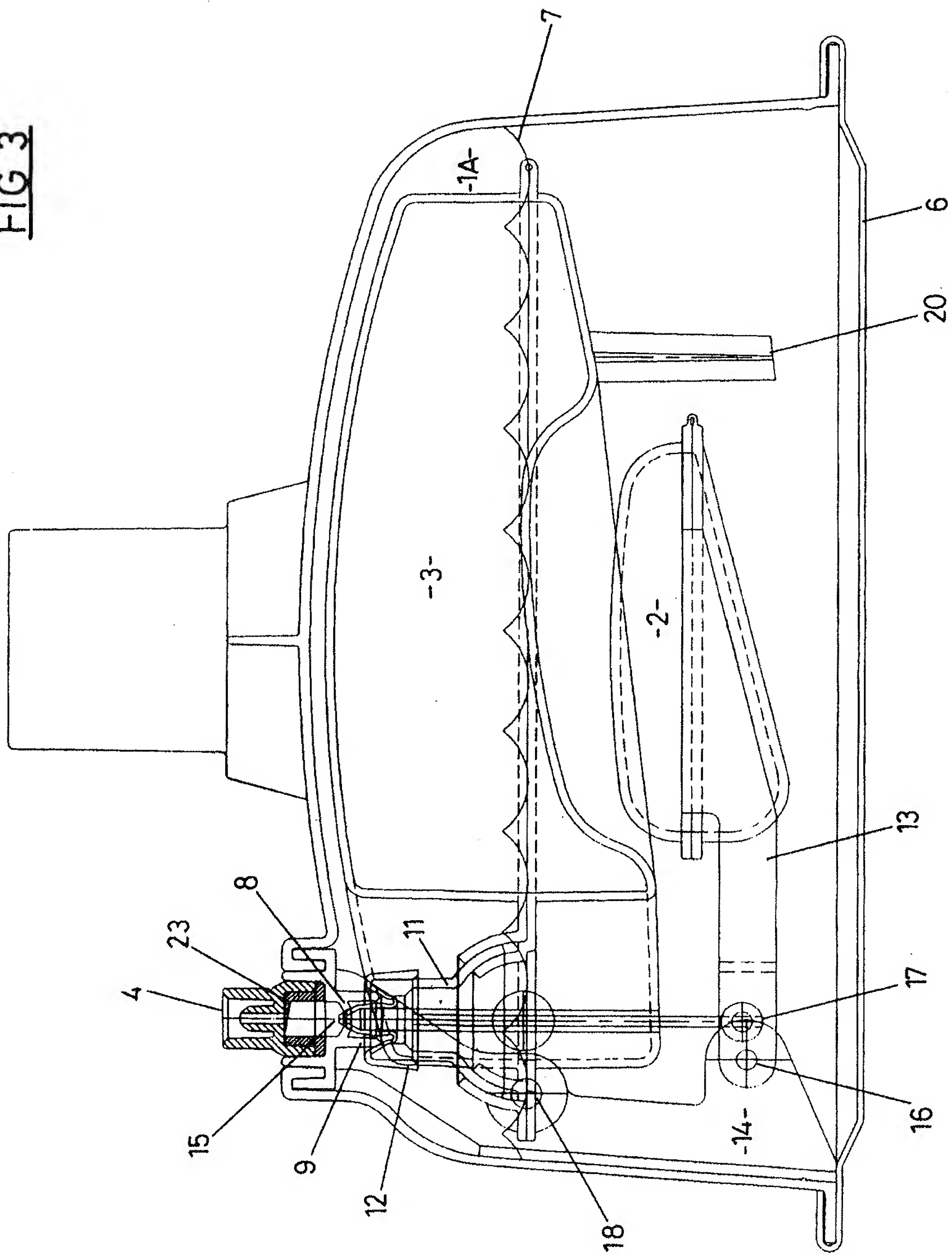


FIG 4

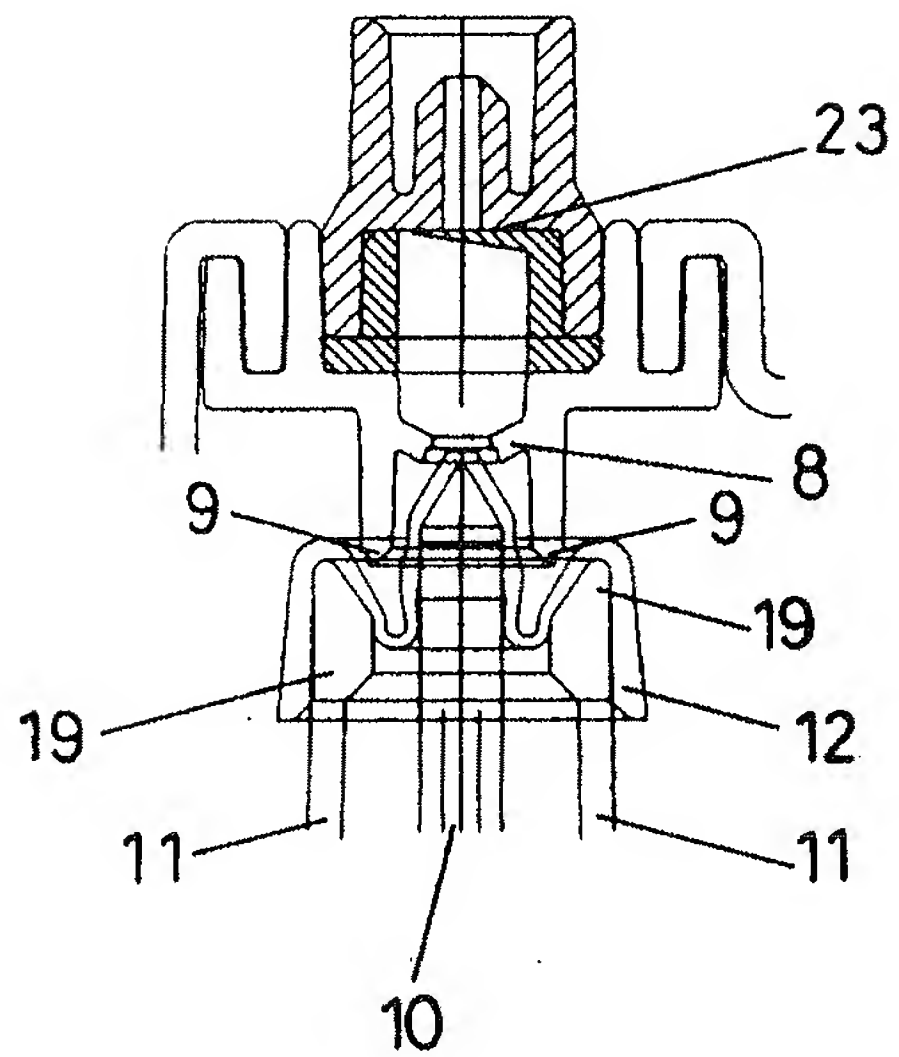


FIG 5

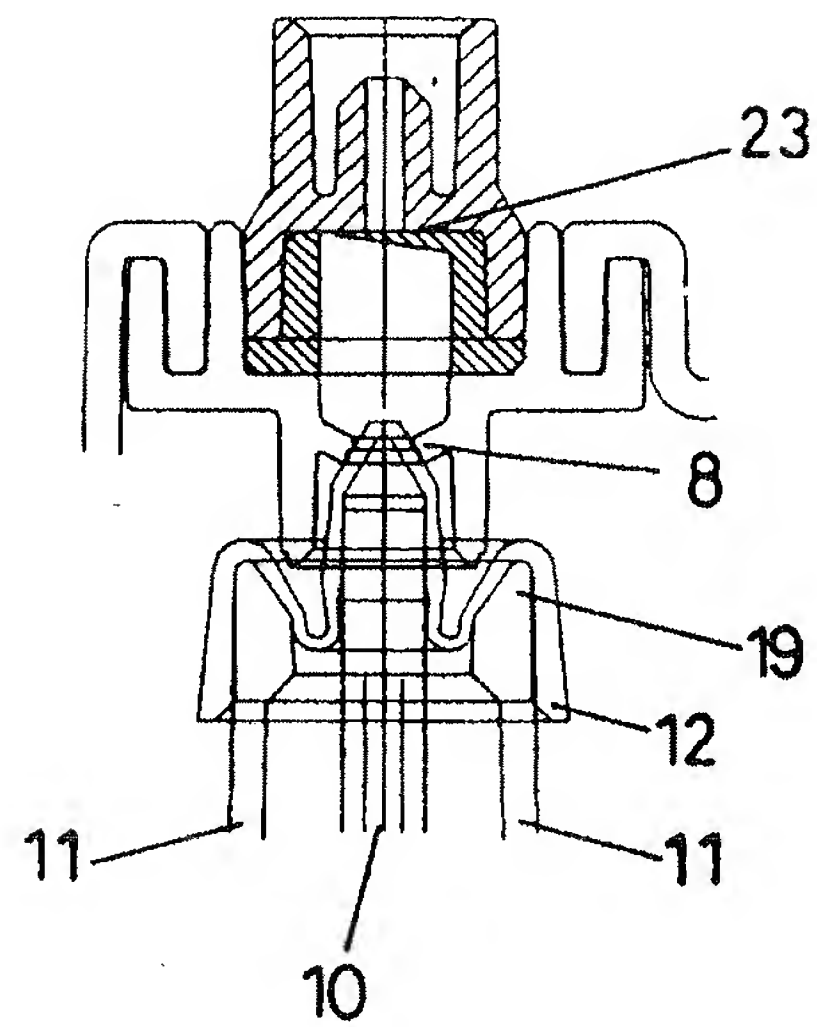


FIG 6

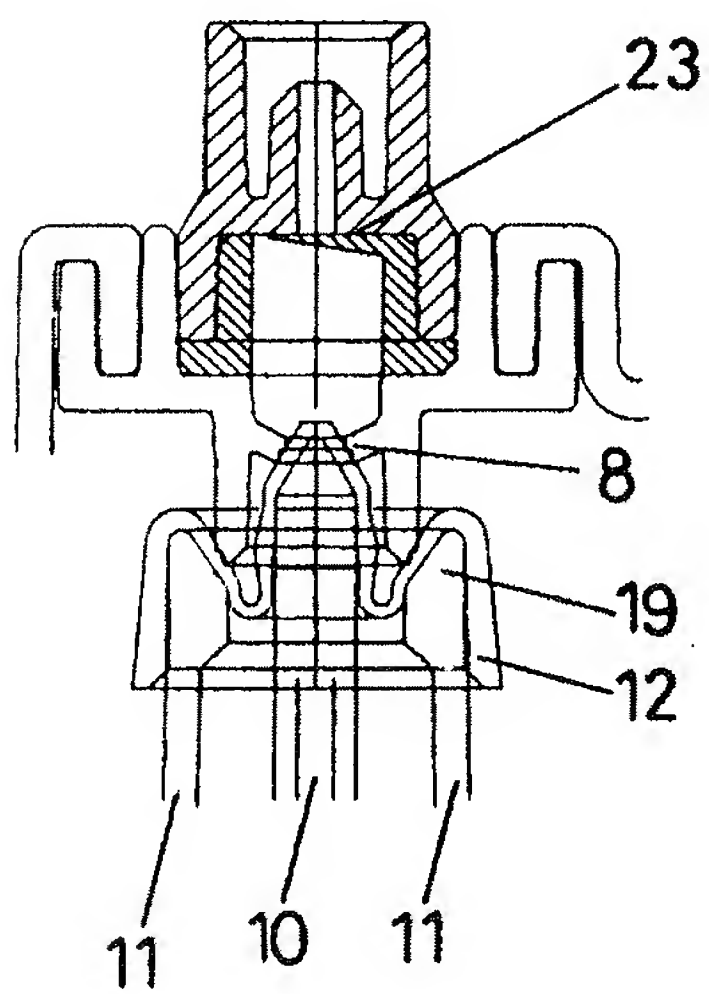
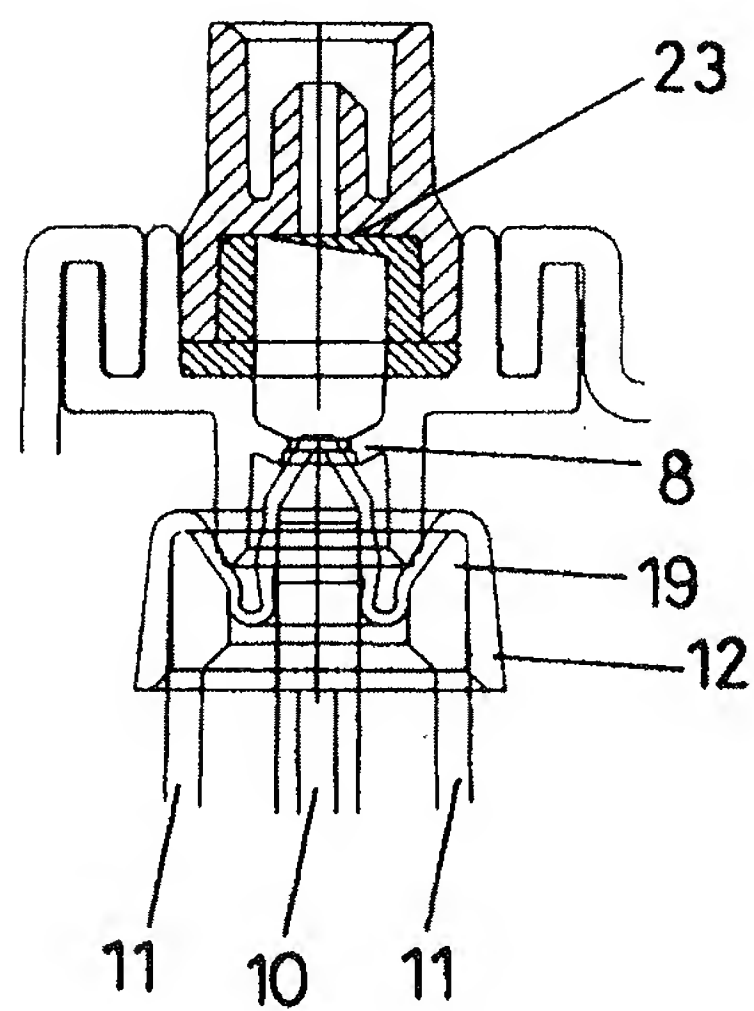


FIG 7



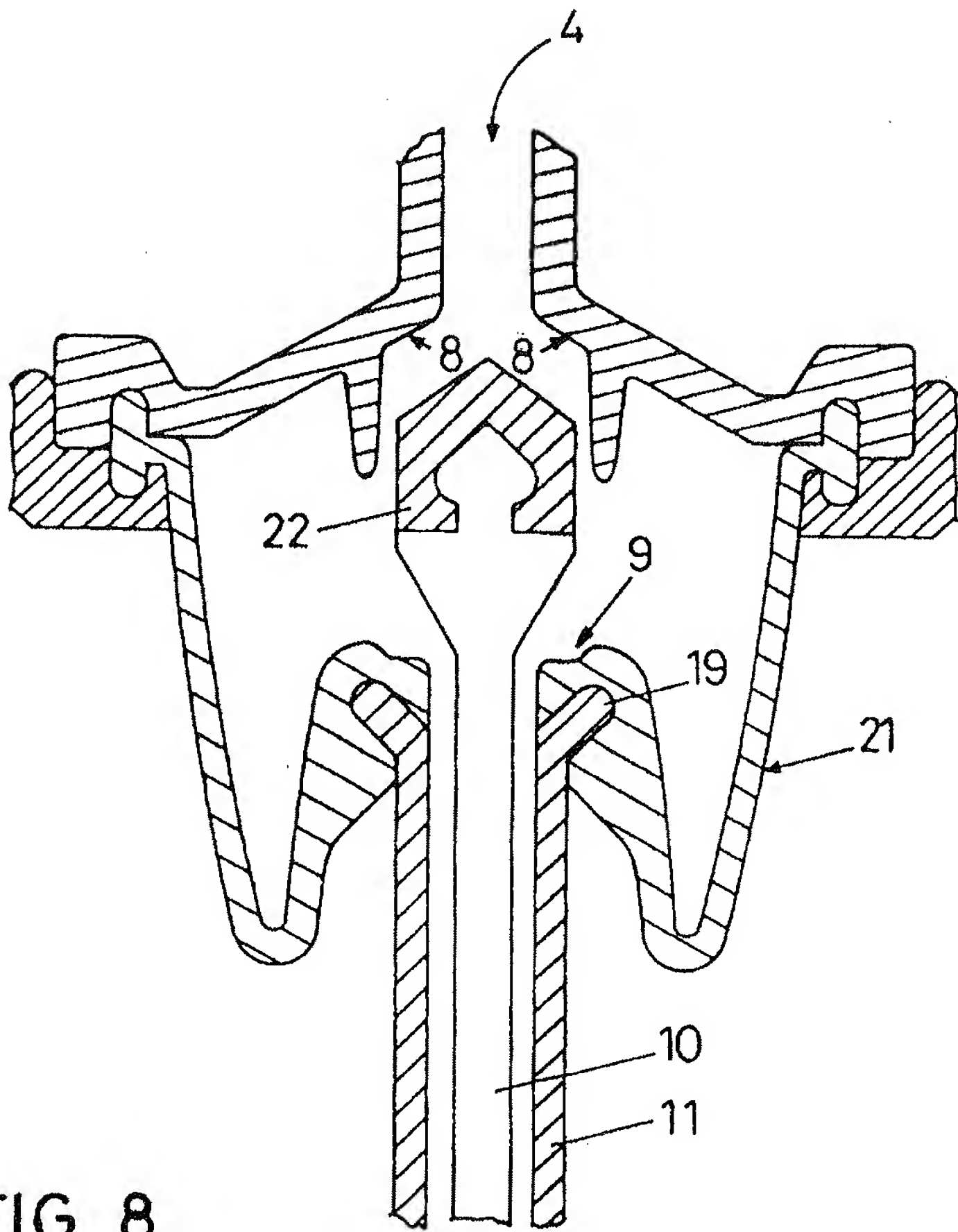


FIG 8

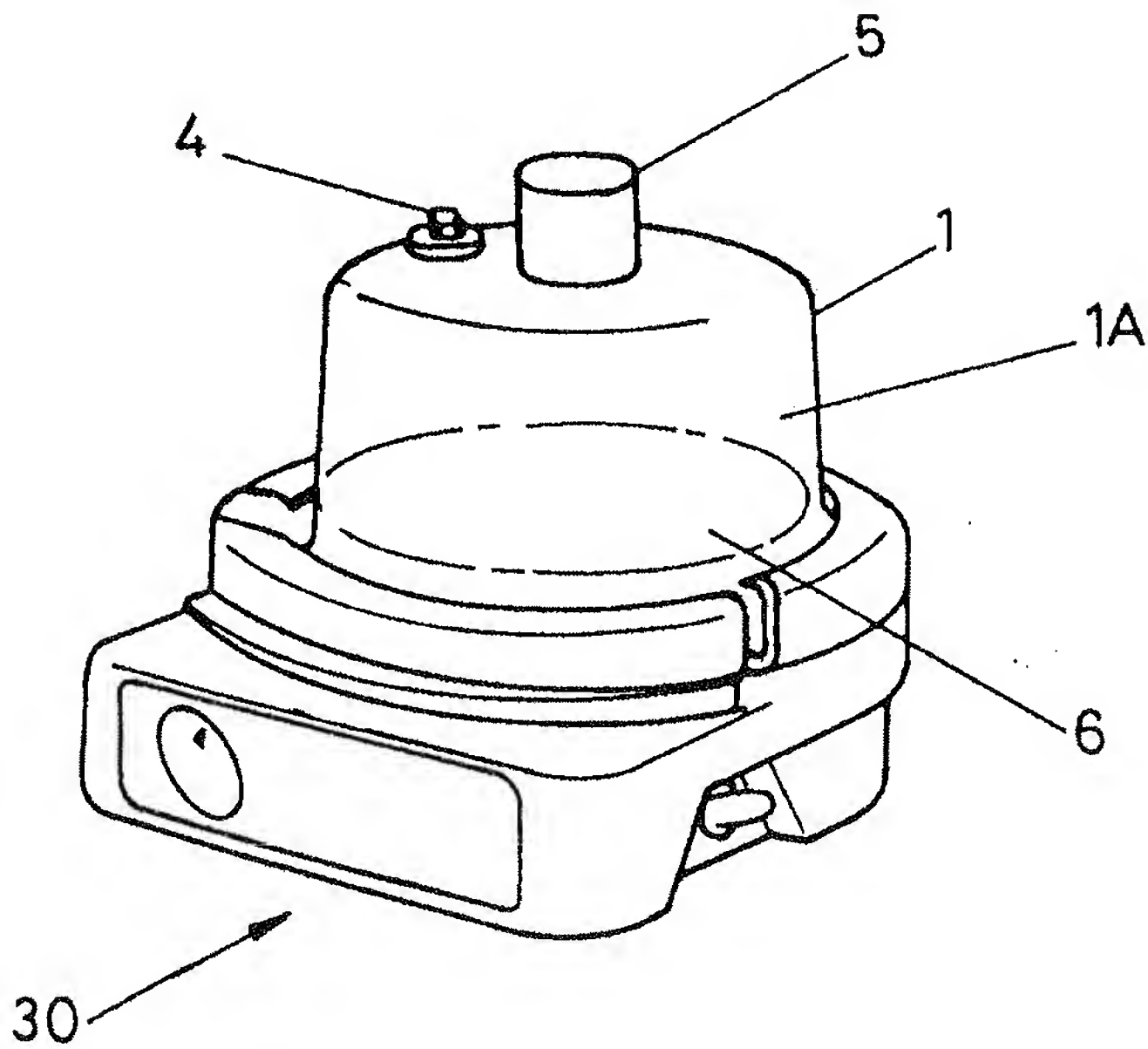


FIG 9



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 93 11 5269

DOCUMENTS CONSIDERED TO BE RELEVANT															
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)												
X,D	FR-A-2 620 043 (FISHER & PAYKEL LIMITED) * abstract; figures * * page 6, line 22 - page 7, line 21 * ---	1,7	A61M16/00												
A,D	US-A-4 529 867 (VELNOSKY ET AL.) * abstract; figures 1,2,5-8 * * column 4, line 42 - column 5, line 15 * ---	1,7													
A	DATABASE WPI Week 8637, Derwent Publications Ltd., London, GB; AN 86-239914 & EP-A-0 193 752 (SIEMENS AG) 10 September 1986 * abstract * ---	2-6,8-12													
A	DATABASE WPI Week 8304, Derwent Publications Ltd., London, GB; AN 83-B0566K & DE-A-31 25 459 (CENTRA-BURKLE GMBH) 20 January 1983 * abstract * ---	2-6,8-10													
A	PATENT ABSTRACTS OF JAPAN vol. 011, no. 071 (M-567)4 March 1987 & JP-A-61 226 353 (NIPPON AIR BRAKE CO LTD) 8 October 1986 * abstract * -----	2-6,8-10													
The present search report has been drawn up for all claims															
Place of search THE HAGUE		Date of completion of the search 10 December 1993	Examiner Zeinstra, H												
<table border="0"><tr><td>CATEGORY OF CITED DOCUMENTS</td><td>T : theory or principle underlying the invention</td></tr><tr><td>X : particularly relevant if taken alone</td><td>E : earlier patent document, but published on, or after the filing date</td></tr><tr><td>Y : particularly relevant if combined with another document of the same category</td><td>D : document cited in the application</td></tr><tr><td>A : technological background</td><td>I : document cited for other reasons</td></tr><tr><td>O : non-written disclosure</td><td>& : member of the same patent family, corresponding document</td></tr><tr><td>P : intermediate document</td><td></td></tr></table>				CATEGORY OF CITED DOCUMENTS	T : theory or principle underlying the invention	X : particularly relevant if taken alone	E : earlier patent document, but published on, or after the filing date	Y : particularly relevant if combined with another document of the same category	D : document cited in the application	A : technological background	I : document cited for other reasons	O : non-written disclosure	& : member of the same patent family, corresponding document	P : intermediate document	
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